
$^{13}\text{C}(\alpha,\text{n}),(\alpha,\alpha)$ 1965Ba32,1968Ke02

1965Ba32: Cross sections for the reaction $^{13}\text{C}(\alpha,\alpha)$ at $\theta_{\text{cm}}=54.7^\circ, 107.9^\circ, 142.6^\circ, 169.6^\circ$ and for the reaction $^{13}\text{C}(\alpha,\text{n})^{16}\text{O}$ at $\theta_{\text{cm}}=0^\circ$ were measured. A beam of $E(\alpha)=2-3.5$ MeV from the 5.5-MeV Van de Graaff accelerator bombarded a self-supporting foils made either from 41.6% ^{13}C -enriched methyl iodide, or from 56.7% ^{13}C -enriched methane with thickness $\approx 15 \mu\text{g}/\text{cm}^2$. Using dispersion-theory analysis, a consistent set of J^π and partial-width values for 11 excitation energies $E_x=8-9$ MeV were obtained. See also (1965BaZY).

1968Ke02: Cross sections of reactions $^{13}\text{C}(\alpha,\alpha_0)$ and $^{13}\text{C}(\alpha,\text{n})$ were measured by bombardment of an $E_\alpha=12$ MeV beam on to self-supporting, 20-30 $\mu\text{g}/\text{cm}^2$ thick, enriched ^{13}C targets at the Van de Graaff facility/Australian National University. Two surface-barrier detectors (for (α,α_0)) and two 2.5 cm \times 5 cm plastic scintillators (for (α,n)) were used to detect particles. Using a dispersion-theory analysis, the J^π and partial width values were obtained for 11 states of ^{17}O with $E_x=9-10$ MeV.

1971Co14: $^{13}\text{C}(\alpha,\alpha)$, $E=15,18,20$ MeV; measured $\sigma(\theta)$; deduced optical model parameters. Enriched targets.

1972Ku19: $^{13}\text{C}(\alpha,\alpha)$, $E=26.6$ MeV; measured $\sigma(\theta)$.

1973Ku18: $^{13}\text{C}(\alpha,\alpha)$, $E=18,19,22,24,25,26.6$ MeV; measured $\sigma(E;\theta)$; deduced reaction mechanism.

1973Le28: $^{13}\text{C}(\alpha,\alpha)$, $E=15-25$ MeV; measured $\sigma(E;\theta)$. ^{17}O deduced resonances.

1974Ku15: $^{13}\text{C}(\alpha,\alpha)$, $E=26.6$ MeV; measured $\sigma(\theta)$.

1987Ab03: $^{13}\text{C}(\alpha,\alpha)$, $E=48,7,54.1$ MeV; deduced model parameters. ΔE -E telescopes. Optical model analyses.

1990Mu19: $^{13}\text{C}(\alpha,\alpha)$, $E=65$ MeV; analyzed $\sigma(\theta)$; deduced model parameters. Microscopic overlap integrals, vertex form factors.

1993AtZZ: $^{13}\text{C}(\alpha,\alpha),(\alpha,\alpha')$, $E=54.1,104,155$ MeV; measured $\sigma(E,\theta)$; deduced model parameters. Coupled-channels analysis.

2012PrZY: $^4\text{He}(^{13}\text{C},\alpha)$, $E=20.0,25.0,30.0,33.0,35.0$ MeV; measured thick target reaction products. ^{17}O deduced yield vs E^* , resonances.

2014My05: $^4\text{He}(^{13}\text{C},^{13}\text{C})$, $E=1.75$ MeV/nucleon; measured reaction products, E_α , I_α . ^{17}O ; deduced $\sigma(\theta)$.

Theory:

1971Te10: $^{13}\text{C}(\alpha,\alpha)$, $E=20,25$ MeV; analyzed interference between states of transferred nucleus.

1974Ch58: $^{13}\text{C}(\alpha,\alpha)$, $E=26.6$ MeV; analyzed $\sigma(\theta)$.

1977Sa19: $^{13}\text{C}(\alpha,\alpha)$, $E=40.5$ MeV; calculated $\sigma(\theta)$ at forward angles.

1978Ze03: $^{13}\text{C}(\alpha,\alpha)$, $E=26.6$ MeV; calculated $\sigma(\theta)$.

1983Go27: $^{13}\text{C}(\alpha,\alpha)$, $E=26.6$ MeV; calculated $\sigma(\theta)$; deduced spin-orbit potential effects.

1987Le29: $^{13}\text{C}(\alpha,\alpha)$, $E(\text{cm})=1.59-4.34$ MeV; analyzed, compiled data.

1988Le05: $^{13}\text{C}(\alpha,\alpha)$, E not given; calculated resonances, Γ . Optical model.

1991Le33: $^{13}\text{C}(\alpha,\alpha)$, $E=1.5-10$ MeV; compiled, reviewed backscattering σ data; deduced regions for ion-beam, depth profiling analyses.

1996Le06: ^{17}O ; calculated levels using parameters for $^{13}\text{C}+\alpha$ cluster system. Semi-microscopic algebraic cluster model.

2010DaZY: $^{13}\text{C}(\alpha,\alpha),(\alpha,\alpha')$, $E=388$ MeV; calculated $\sigma(\theta)$; deduced radii for specified excited states.

2011Og09: $^{13}\text{C}(\alpha,\alpha)$, $E(\text{cm})<300$ MeV; analyzed $\sigma(\theta)$ and diffraction radii data; deduced abnormally large radii for excited states.

2011Og10: $^{13}\text{C}(\alpha,\alpha),(\alpha,\alpha')$, $E(\text{cm})=388$ MeV; analyzed $\sigma(\theta)$; deduced rms radii, diffraction radii, neutron halos in the excited states. Modified diffraction model.

^{17}O Levels

E(level)	J^π	Γ	$E_\alpha(\text{res})$ (keV)	Comments
7972 [†]	$1/2^-$ [†]	69 [†] keV	2110	E(level): from $E_\alpha=2110$ keV. Γ : from $\Gamma_{\text{lab}}=90$ keV with $\Gamma_a/\Gamma=0.03$.
8066 [†]	$3/2^+$ [†]	84 [†] keV	2233	E(level): from $E_\alpha=2233$ keV. Γ : from $\Gamma_{\text{lab}}=110$ keV with $\Gamma_a/\Gamma=0.05$.
8199 [†]	$3/2^-$ [†]	64 [†] keV	2407	E(level): from $E_\alpha=2407$ keV. Γ : from $\Gamma_{\text{lab}}=84$ keV with $\Gamma_a/\Gamma=0.11$.
8334 [†]	$1/2^+$ [†]	8 [†] keV	2583	E(level): from $E_\alpha=2583$ keV. Γ : from $\Gamma_{\text{lab}}=11$ keV with $\Gamma_a/\Gamma=0.44$.
8395 [†]	$5/2^+$ [†]	5 [†] keV	2663	E(level): from $E_\alpha=2663$ keV. Γ : from $\Gamma_{\text{lab}}=7$ keV 2 with $\Gamma_a/\Gamma=0.08$.
8462 [†]	$7/2^+$ [†]	8 [†] keV	2750	E(level): from $E_\alpha=2750$ keV. Γ : from $\Gamma_{\text{lab}}=10$ keV with $\Gamma_a/\Gamma=0.97$.

Continued on next page (footnotes at end of table)

¹³C(α, n), (α, α) **1965Ba32, 1968Ke02 (continued)**¹⁷O Levels (continued)

E(level)	J $^\pi$	Γ	E $_\alpha$ (res) (keV)	Comments
8500 [†]	5/2 ^{-†}	5.0 [†] keV 15	2800	E(level): from E $_\alpha$ =2800 keV. Γ : from $\Gamma_{\text{lab}}=6.7$ keV 20 with $\Gamma_a/\Gamma=0.26$.
8681 [†]	3/2 ^{-†}	52 [†] keV	3037	E(level): from E $_\alpha$ =3037 keV. Γ : from $\Gamma_{\text{lab}}=68$ keV with $\Gamma_a/\Gamma=0.06$.
8875 [†]	3/2 ^{+†}	99 [†] keV	3290	E(level): from E $_\alpha$ =3290 keV. Γ : from $\Gamma_{\text{lab}}=130$ keV with $\Gamma_a/\Gamma=0.50$.
8886 [†]	7/2 ^{-†}	6 [†] keV	3305	E(level): from E $_\alpha$ =3305 keV; not observed in ¹³ C(α, n). Γ : from $\Gamma_{\text{lab}}=8$ keV with $\Gamma_a/\Gamma=1.00$.
8947 [†]	7/2 ^{-†}	23 [†] keV	3385	E(level): from E $_\alpha$ =3385 keV. Γ : from $\Gamma_{\text{lab}}=30$ keV with $\Gamma_a/\Gamma=0.04$.
9142 [‡]	1/2 ^{-‡}	6 [‡] keV	3640	E(level): from E $_\alpha$ =3640 keV. Γ : See also $\Gamma_a/\Gamma=0.45$ (1968Ke02).
9180 [‡]	7/2 ^{-‡}	3 [‡] keV	3690	E(level): from E $_\alpha$ =3690 keV; observed via ¹³ C(α, α_0) only. Γ : See also $\Gamma_a/\Gamma=0.98$ (1968Ke02).
9203 [‡]	5/2 ^{+‡}	5.5 [‡] keV	3720	E(level): from E $_\alpha$ =3720 keV. Γ : See also $\Gamma_a/\Gamma=0.20$ (1968Ke02).
9502 [‡]	5/2 ^{-‡}	15 [‡] keV	4110	E(level): from E $_\alpha$ =4110 keV. Γ : See also $\Gamma_a/\Gamma=0.85$ (1968Ke02).
9723 [‡]	7/2 ^{+‡}	16 [‡] keV	4400	E(level): from E $_\alpha$ =4400 keV. Γ : See also $\Gamma_a/\Gamma=0.70$ (1968Ke02).
9739 [‡]	3/2 ^{+‡}	61 [‡] keV	4420	E(level): from E $_\alpha$ =4420 keV. This level is associated with E _x =9786 keV in Adopted Levels. Γ : See also $\Gamma_a/\Gamma=0.90$ (1968Ke02).
9861 [‡]	9/2 ^{+‡}	12 [‡] keV	4580	E(level): from E $_\alpha$ =4580 keV. Γ : See also $\Gamma_a/\Gamma=0.18$ (1968Ke02). J^π : A doublet was populated and identified as J $^\pi=9/2^+$. Two levels were subsequently identified with (5/2 ⁻) and (1/2 ⁻).
9953 [‡]	7/2 ^{+‡}	107 [‡] keV	4700	E(level): from E $_\alpha$ =4700 keV. Γ : See also $\Gamma_a/\Gamma=0.78$ (1968Ke02). J^π : Associated with 9976 keV: 5/2 ⁺ level in Adopted Levels.
10136 [‡]	5/2 ^{+‡}	138 [‡] keV	4940	E(level): from E $_\alpha$ =4940 keV. Γ : See also $\Gamma_a/\Gamma=0.85$ (1968Ke02).
10167 [‡]	7/2 ^{-‡}	46 [‡] keV	4980	E(level): from E $_\alpha$ =4980 keV. Γ : See also $\Gamma_a/\Gamma=0.15$ (1968Ke02).
10243 [‡]	7/2 ^{+‡}	122 [‡] keV	5080	E(level): from E $_\alpha$ =5080 keV. Γ : See also $\Gamma_a/\Gamma=0.60$ (1968Ke02).
10320 [‡]	(7/2) ^{‡#}		5180	E(level): from E $_\alpha$ =5180 keV.
10412 [‡]		≤ 20 [‡] keV	5300	E(level): from E $_\alpha$ =5300 keV.
10488 [‡]	(5/2) ^{‡#}	75 [‡] keV 30	5400	E(level): from E $_\alpha$ =5400 keV.
10580 [‡]	(7/2, 9/2) ^{‡#}	45 [‡] keV 20	5520	E(level): from E $_\alpha$ =5520 keV.
10626? [‡]			(5580)	E(level): from E $_\alpha$ =(5580) keV.
10702 [‡]	(7/2) ^{‡@}	≤ 25 [‡] keV	5680	E(level): from E $_\alpha$ =5680 keV; observed via ¹³ C(α, α_0) only.
10779 [‡]	(5/2) ^{‡#}	75 [‡] keV 30	5780	E(level): from E $_\alpha$ =5780 keV.
10916 [‡]	$\geq 3/2$ ^{‡#}	60 [‡] keV 20	5960	E(level): from E $_\alpha$ =5960 keV.
11046 [‡]			6130	E(level): from E $_\alpha$ =6130 keV.
$\approx 11253?$ [‡]			$\approx(6400)$	E(level): from E $_\alpha$ =(≈ 6400) keV.

[†] From (1965Ba32) where $\Gamma_n + \Gamma_\alpha = \Gamma$.

$^{13}\text{C}(\alpha,\text{n}),(\alpha,\alpha)$ **1965Ba32,1968Ke02 (continued)**

^{17}O Levels (continued)

[‡] From (1968Ke02). No states overlapping with those of (1965Ba32) were reported.

[#] Tentative assignments from $^{13}\text{C}(\alpha,\text{n})$ angular distribution data.

[@] Inferred from comparison of elastic yield with calculated level shapes.